DOCUMENT RESUME

ED 162 817 **SE 025 014**

AUTHOR	Clarkson, W. W.; And Others
TITLE	Land Application of Wastes: An Educational Program - Introduction and Script.
INSTITUTION	State Univ. of New York, Ithaca. Coll. of Agriculture and Life Sciences at Cornell Univ.
SPONS AGENCY	Corps of Engineers, Washington, D.C.; Environmental Protection Agency, Washington, D. C.
PUB DATE	Jan 78
GRANT	EPA-T-900500
NOTE	27p.; For related documents, see SE 025 015-035; Not available in hard copy due to copyright restrictions; Script marginally legible
AVAILABLE FROM	Van Nostrand Reinhold, 450 West 33rd Street, New York, N.Y. 10001
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	Agriculture; Environment; *Instructional Materials; *Land Use; *Learning Modules; Postsecondary Education; Resources; *Sanitation; *Waste Disposal; *Wastes
IDENTIFIERS	Land Application; *Waste Water Treatment

ABSTRACT

This is the introductory module to the Land Application of Wastes educational program. The module contains information on the content, structure, and dynamics of the program. Also included with the module is a script to accompany a slide presentation. The Land Application of Wastes program consists of twenty-five modules and audio-visual materials. The modules incorporate knowledge from sanitary and environmental engineering, agronomy, soil science, agricultural engineering, economics, and law. (BB)

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ED162817

Land Application of Wastes

An Educational Program

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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New York State College of
Agriculture and Life Sciences
A Statutory College of the State University
Ithaca, New York

INTRODUCTION

Land Application of Wastes -
An Educational Program

January, 1978

SE 025 014

LAND APPLICATION OF WASTES - AN EDUCATIONAL PROGRAM

The objective of this program is to increase the knowledge of engineers, scientists, waste management specialists and other practitioners in the concepts and principles needed to properly utilize the potential of land for the application of wastes. It is designed for individuals concerned with waste disposal alternatives for municipal, industrial, and agricultural wastes. The modules in this Program incorporate knowledge from sanitary and environmental engineering, agronomy, soil science, agricultural engineering, economics, and law.

The program consists of some twenty-five modules and audio-visual materials as appropriate.

Questions about the Program can be directed to:

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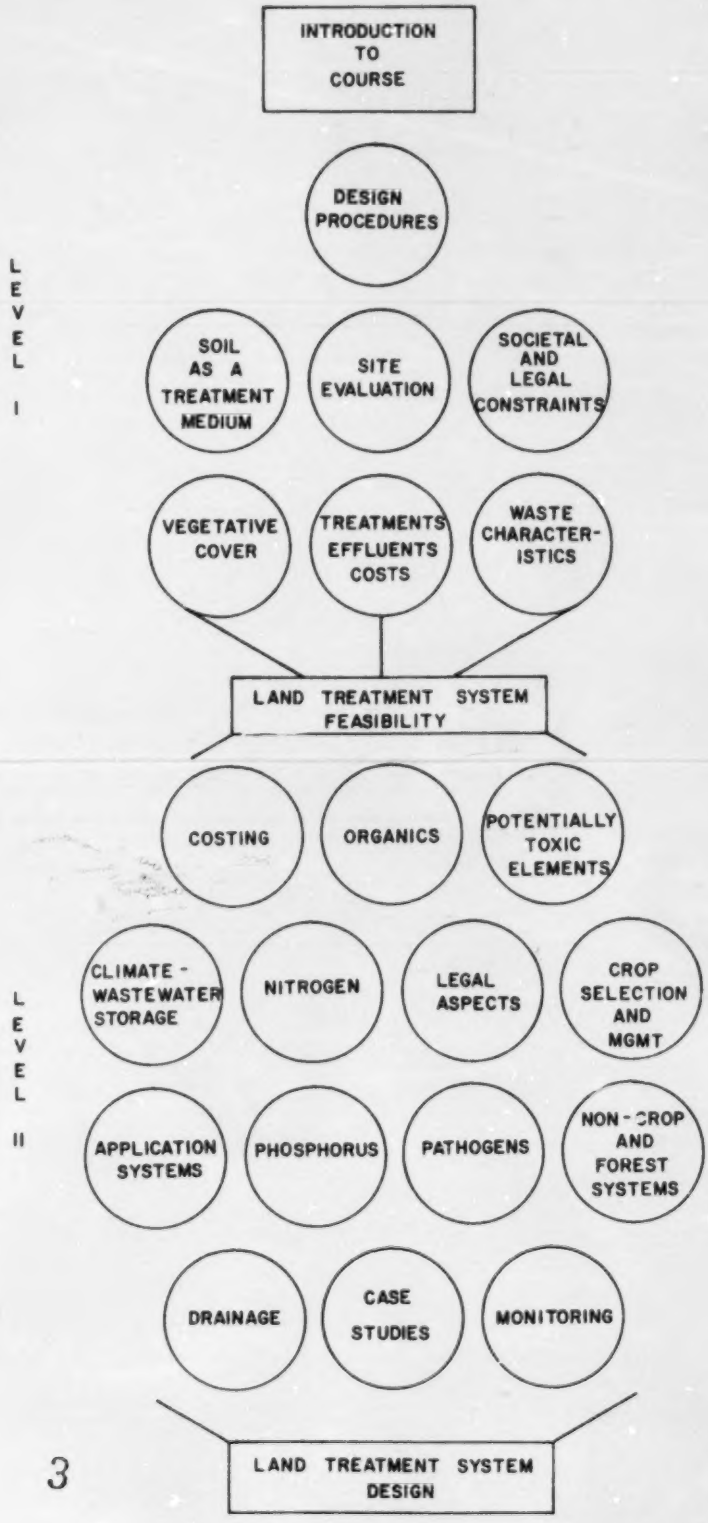

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Summary

The purpose of this module is to acquaint the participant with the program of instruction entitled "Land Application of Wastes - An Educational Program." The introductory module includes information on the content, structure, and dynamics of the Program. Upon completion of the Introductory Module, the participant will be prepared to begin the Program.

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Land Application of Wastes - A Brief Overview

In the nineteenth century it became relatively common for municipalities to operate "sewage farms". Some of those facilities were successful as measured by standards of the day such as an absence of excessive odors or standing water. Eventually, as urban expansion encroached on available land and technological interests turned to the design of sewage treatment plants, most sewage farms were abandoned. Although many land treatment sites operated successfully in the ensuing years, it is only since passage of the Water Pollution Control Act Amendments of 1972 (PL 92-500) that land application as a waste management alternative has been re-emphasized. Subsequent policy statements by the U.S. Environmental Protection Agency have mandated that land application be considered for any proposed wastewater treatment facility to receive federal funds.

Critical evaluation of those factors that impose specific limitations on the land application of wastes is needed. Specifically, it is necessary to evaluate:

a) the characteristics of the wastewater or sludge

b) the impact of nitrogen, phosphorus, and potentially toxic elements on the soil system, vegetative cover, runoff water, and groundwater

c) the interactions between the soil system and wastewater constituents

d) available sites with the necessary characteristics for waste treatment

e) the social and legal constraints

f) the costs

g) the effect of the proposed land application system on present and future regional land use patterns.

Thought must be given to designs employing combinations of conventional systems and land application. Such an evaluation must include the broad implications of the limiting factors with respect to both land application in general and to the specific site under consideration. Modification of specific waste characteristics, site conditions, and land use to relieve limiting features may be possible. Examples of such modifications might include underdraining certain soils so that larger hydraulic loads could be applied, wastewater pretreatment to reduce heavy metal content, or frequent cropping to achieve a higher rate of nutrient removal. Techniques such as these and others are covered in the modules of this program. The modular format is discussed in the next section.

The Educational Program - Structure

The success of a land application system rests on scientific, legal, and social fundamentals and practices. It is necessary to integrate these items, to discuss their implications, and to provide a level of practical experience.

The objective of this educational program is to develop a better understanding of the capacity of the soil to assimilate wastes. The program is designed for engineers, scientists, planners, waste management specialists, and other practitioners in the area of environmental protection. Land application of municipal, industrial, and agricultural wastes is addressed. Knowledge from several disciplines, including sanitary, environmental, and agricultural engineering, agronomy, soil science, economics, and law are incorporated into this program. In order to present this diverse array of information in a meaningful way, this program is presented in modular format. This format also allows for variation in both the rate at which individuals are exposed to new information, and the degree of mastery that can be expected per unit of study time.

The Modules

The basic unit of formal instruction is the module. A module is a self-contained learning packet focused on a specific concept, or set of highly interrelated concepts. Within the module, the program participant will find information on what he can expect to learn from the module, how the module fits into the entire program, and a discussion of the specific aspect of land application of wastes being addressed. Modules require from 0.5 to 3 hours of study time.

While all modules are presented in a written format, the majority are designed to be accompanied by audio-visual presentations, known as audio-tutorials, or A-T units. The audio-tutorials may be a core portion of the module, or they may be review or supplementary units. Written scripts are provided along with the tape and slide A-T presentations, and several A-T units include supplementary booklets for further study.

Each module includes a set of learning objectives. The objectives indicate to the participant what he can expect to learn from the module. Thus, if

the objectives of the module can be met by the participant without completing the module, then it is clear that this particular module can be passed over by the participant. Objectives are usually presented as a series of activities which the participant will be able to do after completing the module. For example, an objective for this module might read as follows:

> Upon completion of this module, the participant should be able to:
>
> Enter into the program entitled "Land Application of Wastes - An Educational Program"; find appropriate modules to begin work, and begin these modules.

A summary of the information covered in the module also is presented in the preliminary pages.

The table of contents of the module is presented in outline form. This allows the participant to discover precisely what information is covered in the module, and where it is found. The reader should carefully read the major titles and their immediate subdivisions, and then reflect on how those topics might "fit" with respect to the existing knowledge and insights the reader has about the topic. Consciously trying to fit the general information of a module to one's own store of knowledge is the first and surest step in making effective use of the modular format. That preliminary effort is the most effective way an individual has to utilize the module so that it is supportive of, and integrated into, the knowledge of the reader. If the participant can complete only several of the objectives, he is able to identify sections in the module which would allow him to learn the material needed to complete the remaining objectives without having to cover material already familiar. A list of tables and list of figures is also provided. In some of the modules, following the outline and table of content information there is a glossary of words, terms, and concepts which are used in the module.

The modules are printed on two-thirds of the page, with particularly cogent points appearing in the right-hand margin. This method allows the participant to skim through the module without reading it verbatim. The marginal notes should also be helpful for reviewing the module.

Since each module is considered to be a self-contained learning packet, it is necessary for the participant to be sure he has learned the content of the module to a sufficient degree. By returning to the Module Objectives and answering them, the participant is assured that he has in fact learned what was intended. If the objectives still cannot be answered, the participant has the option of returning to any or all parts of the written module or audio-tutorial for review, or of speaking with a staff member (in a workshop setting).

While each module is considered to be an individual unit, it must be remembered that all modules are designed to be an integral part of the entire educational program. Thus, there is extensive cross-referencing between modules. As the participant proceeds through the program, the individual modules will form an integrated package of information. Let us now take a look at how the individual modules are integrated into the entire program.

The Design Problems

In order to bridge the gap between an academic learning experience, such as this program, and the real-life situations faced by personnel in the field, a framework which approximates the design procedure used by engineers has been included in this program. This framework is described in the module, "Design Procedures for Land Application of Wastes".

Level I Design

The design procedure identifies two levels of specificity. At the first level (Level I), information is presented on all topics relevant to land application of wastes. However, this information is general, and by necessity many details are not included. Table 1 lists the Level I module titles.

Table 1. Introductory modules tend to center attention on broad topics and stress interrelationships between fundamental concepts.

Title
Societal and Legal Constraints
Site Evaluation: General Criteria - Information Sources
Soil as a Treatment Medium
Treatment Systems, Effluent Qualities, and Costs
Waste Characteristics
Design Procedures for Land Application of Wastes
The Role of Vegetative Cover

After satisfactorily completing all Level I modules, the participant should be able to arrive at an initial feasibility decision for a specific design problem. At this point, the participant should be able to state what the limiting factor to land application may be, what social aspects need further investigation,

possible sites for a land application system, and generally whether land application looks like a viable waste management alternative for that particular situation, in terms of initial cost and technical comparison with conventional alternatives.

Level II Design

The participant is now ready for Level II. The Level II modules contain information needed to arrive at more detailed design parameters such as hydraulic loads, application rate, land area needed, costs, and so on. After completing Level II modules, a much more detailed problem evaluation is possible. Table 2 lists the titles of Level II modules.

Table 2. Level II modules provide more detailed information for completion of design problems.

Title
Climate and Wastewater Storage
Pathogens
Costing Land Application Systems
Potentially Toxic Elements
Waste Application Systems
Non-crop and Forest Systems
Case Studies Reviewed
Nitrogen Considerations
Legal Aspects
Organic Matter
Monitoring at Land Application Sites
Phosphorus Considerations
Crop Selection and Management Alternatives
Drainage for Land Application Sites

Module and Program Sequences

The program consists of over twenty modules, plus design problems. To be consistent with the philosophy of individualized learning in the Program

there is no formal sequence of modules. As noted, each module is a self-contained study unit. To start the Program, each participant should choose one of the six Level I modules. Since there is no rigid sequencing, the Level I modules may be completed in any sequence the participant desires. The Level I modules can be completed in 3 to 9 hours of study time.

It is suggested that each participant assume that he has been approached by a municipality or an industrial firm for advice about a proposed land application system. With this focus, a participant can raise some intelligent questions, gather pertinent information, and relate the information in the modules to a real situation. To reinforce this focus, each participant will be working on a design problem.

The design problems are included only to provide a real focus for the fundamental information and to place the information in a real rather than abstract context. The participants should not consider solution of the design problem to be the most important part of the Program. The design problem is merely to facilitate the acquisition and use of the basic information.

It is important to avoid thinking of modules as equivalent to chapters of a book or of thinking of the total packet of modules as representing a book. Each module should be considered as a unit of information that may or may not be significant to an individual participant. Not all modules will or should be "covered" during the time span of this program. Each participant may select a different set of modules for study. The Program is designed to provide the information the participant needs to increase his store of useful, meaningful knowledge rather than to force him to cover all the information exhaustively.

The Educational Program - Dynamics

Whereas the modules constitute a large portion of the current knowledge of land application of wastes, they are not designed to stand alone as an educational tool. The program is designed to be transmitted over a 4 1/2 day period, in a workshop setting, using not only the written and audio-tutorial modules, but also guest lecturers, intensive staff-participant, and participant-participant interactions.

Each participant enters this program as an individual. The intent is to enable each participant to retain his individuality yet to benefit from the other participants and the resource personnel. Within the group, therefore, there will be a pool of ability which each individual is free to utilize.

Resource Personnel

The staff represents one major source of guidance and information. Enough staff are provided to meet each participant's need for guidance as quickly as possible. Guest speakers - experts with various backgrounds in specific and general aspects of land application - are part of the Program to serve as additional resource personnel. Participants are encouraged to interact individually or in groups with these speakers. The fellow participants represent a wide range of pertinent knowledge and experience. While each participant is recognized to be moving through the Program as an individual, the Program format is designed to encourage interaction and support.

The Team Approach

Participants will be given realistic design problems based on the scenario of a client approaching a consultant with some limited information at hand and requesting advice on the feasibility of land application to solve a given problem. Each participant will be asked to select one "interesting" situation for study and the participants will be divided into study teams.

Each team will meet with a staff member and begin to consider the problem. The staff member will act only to gently direct the discussion

if it strays too far off target. He or she will act as a resource person to indicate where specific information may be found. The staff member is not to supply factual answers except when necessary to avoid delays in the Program. Working together, the team should develop the background information necessary to assess the general feasibility of land application for the specific problem (Level I). A more detailed analysis and feasibility will occur in the subsequent part of the Program (Level II).

After assessment of the overall feasibility, the group will prepare a short oral report on areas needing further consideration and the conclusions reached. These considerations and conclusions should reflect a sound grasp of the fundamental concepts presented in the Level I modules. The entire group of program participants will assemble and each team will present its report and respond to questions from the group.

After presentation of the preliminary reports, the teams will again meet separately with their staff member. Each team will retain its problem but will now concentrate on obtaining a more detailed analysis of the feasibility of land application for the specific problem. To do this, the team should review the remaining modules of the program (Level II).

Participants are encouraged to consult with any staff member or guest lecturer. These consultation sessions must be considered one of the more important benefits of this modular approach. Maximum staff-participant interaction (individuals or groups) will come about over questions and difficulties inspired by these problems. The advantage of such consultation sessions is the one-to-one interaction in which topics of immediate and mutual interest are discussed from a more or less common pool of information.

Several study hours may be needed to cover the modules. Throughout this work time, however, participants should recognize that the important part of the Program is the understanding of the material in the modules.

Although each member of the team may not have completed every module, all modules should be covered by one or another participant before reaching a conclusion on the design problem. By pooling information learned from the modules and from participant interaction, the Level II design analysis can be prepared.

Design problem analyses for Level II will again be presented to the entire group. Questions are encouraged. In this manner all participants can share the problems and experiences of other teams. The Level II presentations complete the design problem phase, and a review and feedback session completes the Workshop.

ACKNOWLEDGEMENTS

The development of this program and the preparation of the modules resulted from the collaboration of many individuals in the College of Agriculture and Life Sciences, a statutory unit of the State University at Cornell University, and others. The primary faculty and staff associated with the project were:

PROFESSIONAL STAFF

W. W. Clarkson, Research Associate	Agricultural Engineering
G. S. Friedman, Research Associate	Education
A. C. Plescia, Production Coordinator	Agricultural Engineering

PRINCIPAL FACULTY PARTICIPANTS

W. J. Jewell, Agricultural Engineering	Principal Faculty Advisor
R. C. Loehr, Environmental Studies Program	Project Coordinator
J. D. Novak, Education	Principal Faculty Advisor
E. L. Stone, Agronomy	Principal Faculty Advisor

This program was supported in part by grant T-900500 from the Academic Training Section, U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers.

The current modules are based on modules developed during the initial phase of this project (1974-1976). Other personnel involved with writing or editing initial modules of the program included:

G. A. Garrigan, Education
S. D. Klausner, Agronomy
C. E. Morris, Education
D. F. Smith, Agricultural Engineering
J. E. Stone, Agronomy

M. M. Bogin edited copy and contributed to written and audio-tutorial modules. S. M. Dabney was the primary author of the Crop Selection and Non-crop and Forest Systems modules.

J.K. Krizek, A.L. Liebermann and R.H. Nagell contributed art work and graphic design. L.A. Martin, A.C. Plescia, B.C. Littlefair and others provided secretarial assistance. D.P. Willmot prepared and processed audio-tutorial materials. Audio-tutorial program was narrated by K. Marash.

Other faculty assistance was provided by W.H. Allaway, D.R. Bouldin, D.J. Lathwell, G.W. Olson, and P.J. Zwerman. Technical assistance of various kinds was provided by R. Batkin, S. Haeni, W. Messner, D. Payne, D. Way, G. MacCaskill, and D. Krizek. Thanks are also due to many other members of the Cornell community who shared time, ideas, and materials.

Personnel of the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory, Hanover, N.H. and Office of the Chief of Engineers in Washington, D.C. reviewed the written and audio-tutorial modules. The audio-tutorial modules were also reviewed at the National Training and Operational Technological Center of the Environmental Protection Agency, Cincinnati, Ohio.

State environmental regulatory agencies provided land application guidelines. Many other individuals, companies, and federal agencies provided technical information, comments, and visual materials. Their generosity has made a major contribution to the program.

RETURN TO LESSON PACKAGE

Script to Accompany the A-T

INTRODUCTORY MODULE

January, 1978

SE 025 014

(Slide 1) This module serves a dual purpose (Slide 2). It introduces land application as a way of treating wastewater and sludge and it introduces the learning package that deals with land application. At the end of this module the participant will begin to have an idea about the possibilities for the land application of wastes. The participant will also begin to see that the learning package has been designed to enable him to learn as efficiently and thoroughly as possible.

Land application was once the preferred method of waste treatment. In the late 1800's and early 1900's it was relatively common for municipalities to operate "sewage farms". Some of these farms were successful and are still in existence in England, Europe, and Australia (Slides 3 and 4).

In the early part of this century, however, most sewage farms were displaced by treatment processes that discharged effluent to surface waters. Sewage farms were abandoned as the technology of sewage treatment advanced as illustrated in Slide 5 of a sewage treatment plant. This trend has increased to the point where we call this type of sewage treatment, conventional treatment. Expanding urban centers have encroached on land that was once available for sewage farms.

There has always remained an interest in waste treatment other than conventional treatment. This has been true for several different industries, especially the food processing industry, and for a number of smaller communities that could not afford the investment, operating and maintenance costs of conventional treatment, but still wanted superior waste treatment (Slides 6 and 7).

Since 1972 when Congress passed PL 92-500, the Federal Water Pollution Control Act Amendments, there has been a renewed emphasis on land application as a waste treatment alternative (Slide 8). Land application is now viewed as the preferred method of treatment for many systems. It must be considered in the proposal for any new or updated sewage treatment facility because it offers the possibility of eliminating the discharge of pollutants to surface waters, while remaining cost effective (Slide 9).

Today, the increased volumes of municipal and industrial wastewaters and sludges are requiring increased capacity of treatment facilities. There are also too many cases of these facilities being inoperative for long periods of time with the treatment being completely short circuited, indicated in Slide 10

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Today, the increased volumes of municipal and industrial wastewaters and sludges are requiring increased capacity of treatment facilities. There are also too many cases of these facilities being inoperative for long periods of time with the treatment being completely short circuited, indicated in Slide 10

from a study of only 312 California conventional treatment systems. These facts considered along with the pollution of surface waters causing eutrophication (Slide 11) and the consequent waste of valuable natural resources and groundwater in sewage (Slide 12), indicates that treatment processes, such as land treatment should receive greater consideration.

Consequently, PL 92-500 and clarifications of the amendments by the EPA, specify that land application techniques, such as the irrigation system in Muskegon, Michigan, shown in Slide 13, be given preferential consideration as the treatment for new or expanded wastewater treatment facilities.

The purpose of this Land Application of Wastes Educational program is to help those associated with planning, designing, operating, evaluating or regulating waste treatment facilities gain knowledge concerning all aspects of land application (Slide 14). These aspects not only include the technical aspects that are required for the design and operating phase of a project, but also include the social, legal, and public health aspects that will enable the community at large to understand and thereby properly utilize land treatment. Knowledge from several disciplines including sanitary, environmental and agricultural engineering, agronomy, soil science, economics, and law are incorporated into this program (Slide 15).

Developed at Cornell University's College of Agriculture and Life Sciences, this educational program was funded by the United States Army Corps of Engineers and the Environmental Protection Agency (Slide 16). The program consists of several different parts and is intended to be used in a particular format. The format and parts are indicated in Slide 17. The program is designed to be used in a workshop or seminar situation, with actual design problems as the focus of the workshop. The written modules and the audio-tutorial lessons are constructed to help solve the design problems as well as to teach the main body of knowledge concerning land application. Distinguished speakers in the area of land application, a group of reference materials and the personal attention of the program staff round out the educational program.

Although the learning materials are used by individuals, it has been found that there are advantages to the interaction that takes place in a workshop or seminar setting (Slide 18). These workshops include individuals from diverse points of view. Even though each member brings his individual experience

to the workshop, the group has come together for the same purpose--that is to learn about the land application of waste(Slide 19). This allows participants to draw upon the experience of others while adding their own unique set of experiences in helping the others. This interaction is a very important part of the learning process.

The participants in the workshop do not simply learn about land application in the abstract. The participants break up into groups of four or five. Each group works on an actual design problem similar to the one in Slide 20, that is the focus of their efforts throughout the workshop. The culmination of the workshop will be a relatively detailed design for a waste treatment system that satisfies the design problem. The purpose of the design problem is to show the possibilities and options available for land application of wastes. Use of an actual design problem also helps integrate and consolidate the newly learned information so that it is understood, remembered, and organized.

In order to present the main body of information in a meaningful way, two methods of study are used - the written modules and the audio-tutorial lessons. Both of these allow for variation in the rate of learning and the degree of mastery desired. Each module or lesson concerns a specific aspect of land application. The titles of the modules and lessons are indicated in Slide 21.

The learning package is divided into two levels. Level 1 consists of those lessons or modules that introduce land application. Their titles are indicated in Slide 22. They cover the subject matter in a general way and serve to organize the more detailed portion of the package that follows. The Level 1 part of the package enables those in the workshop to decide on the feasibility of land application for the design problem. This process is guided by Module 6, "Design Procedures". Level 1 also helps define the waste characteristic in the problem that will be most limiting for land treatment. Slide 23 indicates the idea of a limiting characteristic. In this case Nitrogen is limiting because it requires the greatest amount of land area for adequate control.

The titles for the Level 2 portion of the learning package are shown in Slide 24. These modules enable the learner to design a detailed land appli-

cation system. The treatment capabilities of the soil-plant system are discussed in relation to particular constituents in the waste (Slide 25). Because of variations in the waste being treated, the soil-plant system, the climate and the land available, each system that is designed will be unique. The Level 2 lessons, however, will provide suggestions for system design, storage size and loading rates as well as where to obtain the information necessary to design a particular system. This information will be provided for the design problem. The Level 2 lessons also detail ways to work with the community so that it will understand a land application system.

The written modules and the audio-tutorial lessons generally contain the same information. The audio-tutorial lessons present the material in three basic ways as indicated in Slide 26. The material is heard from the tape, read from the script provided with each lesson, and seen from the slides that go along with each lesson. These three modes of presenting information have been found to be most effective for meaningful learning. Each of the written modules or the A-T lessons (as audio-tutorial is called) are designed for the most efficient learning. Any portion of the A-T or the modules can be reviewed or repeated for clearer understanding. Each is meant to be used individually. The slides are all numbered in the A-T lessons and keyed to the script. If the learner wishes to repeat a portion, he only needs to find the proper place on the tape and return to the corresponding slide, as shown in Slide 27. Each lesson and module has a list of objectives at the beginning. These objectives not only indicate what the learner should know when he finishes the module, but helps organize the information for the learner and helps emphasize what is important in the lesson. It is very important, therefore, to study the objectives carefully, and to refer to the objectives during the program. As shown in Slide 28, the objectives are found on a separate page in the written module. In the A-T lessons, the objectives are found in an envelope that is located in each lesson box (Slide 29). The recording will direct the learner to stop the tape, find and study the objectives. These objectives may be kept for reference during the A-T lesson.

There will be other times when the listener will be directed to a supporting booklet, like the one shown in Slide 30. These booklets are an important part of the learning package and should be referred to when so directed by the tape. The booklets (Slide 31) often contain sample problems to be

worked out to obtain full understanding of the subject matter.

The workshop also involves experts in specific areas relating to land application (Slide 32). Besides giving a brief lecture these experts often are available during a portion of the workshop to answer questions and add their unique perspective to the design procedure. This allows the participants to obtain up-to-the-minute information on many of the quickly changing subject areas related to land application (Slide 33).

During the workshop hours and usually into the night one or more of the workshop staff is available. A staff member will work with each group on the design problem (Slide 34). When a question arises concerning material in the modules or A-T lessons there will usually be a staff member close by, ready to either answer the question immediately or find the answer. The staff has been working in the land treatment area for an extended period of time and is knowledgeable in all phases of the subject matter.

The week long workshop culminates in a finished design by each group of participants. One of the facts that people who work in the wastewater field must live with, however, is that even the best design must still face a trial by fire (Slide 35) or usually several trials-the public hearing. One of the activities of the workshop is a simulated public hearing, involving all of the participants and staff of the workshop. Slide 36 shows the public hearing from a previous workshop. This portion of the workshop is perhaps the one that was found to be the most valuable by past participants. It allows the designer to understand better the positions of different segments of the community and ways to deal with these segments. In actuality, public hearings and community misinformation kill more land treatment projects than any other factor.

At the end of the program the participant has studied a design problem that can be handled by land treatment, learned a body of knowledge in this area, solved the design problem with the help of consultants and participated in a public hearing. This program will allow the participant to critically evaluate those factors which impose specific limitations on the land application of wastes as well as the advantages and cost of this type of waste treatment. This, briefly, is the Cornell University Land Application of Wastes Educational program (Slide 37).

The rest of this A-T lesson introduces the participant to the major concepts of land treatment and directs him to the modules pertaining to specific subjects concerning land treatment.

Land Application is presently practiced throughout the United States with more than 360 systems in operation or in the development phase (Slide 38). The number continues to increase as the cost of conventional waste treatment goes up.

Land application systems are classified primarily according to the capability of the particular soil to transmit water from the soil surface to the groundwater. Rapid infiltration systems are suited to soil with high water transmission capabilities...irrigation for moderate transmission capabilities...and overland flow for low transmission of water (Slide 39).

Irrigation as shown in Slide 40 involves applying wastewater to the land by spraying or surface spreading to support plant growth and treat the wastewater. This method is the most commonly used land application technique.

In rapid infiltration (Slide 41), sometimes called "infiltration-percolation", wastewater is applied to the soil by spreading in basins or by spraying and is treated as it travels through the soil matrix. Less land is needed than with irrigation. Vegetation is generally not used although grass is grown in some cases.

In these systems, wastewater is applied to defined basins so that it percolates down to recharge the groundwater as shown in Slide 42. Principal treatment of wastewater occurs as it percolates through the soil.

In overland flow as shown in Slide 43, wastewater is applied on the upper reaches of sloped terraces of relatively impermeable soils and allowed to flow across the planted surface to runoff collection ditches. Renovation is accomplished by chemical, physical, and biological means as the wastewater flows in a sheet through the vegetation and litter.

Such an overland flow system is shown here, in Ada, Oklahoma (Slide 44). Extensive research indicates that the overland flow technique can be practical for use in small communities. Module 14, "Case Studies Reviewed", describes specific land treatment systems throughout the United States.

The selection of a specific treatment method will be influenced by site characteristics such as climate, topography, and soil type (Slide 45). These subjects are discussed in Module 2, "Site Evaluation", Module 8, "Climate and Wastewater Storage", and Module 3, "Soil as a Treatment Medium".

Cold temperatures or long periods of rain may restrict the use of the land application system. Adequate storage capacity must be determined based on the expected number of days of nonapplication and designed into the system (Slide 46). Module 8, "Climate and Wastewater Storage", discusses this extensively.

The storage or retention of the wastewater prior to land application as shown in Slide 47, may also serve as minimum pretreatment required by some state departments of health. See Module 16, "Legal Aspects", for a closer examination of state regulations and guidelines.

Topography also is important in selecting a site (Slide 48). The cost of preparing the land and the amount of erosion damage generally goes up as the slope of the land increases. Although relatively level terrain is preferred for most systems, some land application methods such as shown in Slide 49, can be adapted to rolling land with up to 15 percent slope, depending on the soil type and vegetative cover. Consequently, the control of surface runoff (Slide 50) is important to the successful operation of all land treatment systems.

When establishing the rate of wastewater application, the engineer must consider many factors, primarily soil depth, minimum depth to groundwater, and soil type.

After determining the soil type, the general range of application rate can be determined as shown in Slide 51. Clays and clay loams are best suited for overland flow. Loamy soils are generally preferred for irrigation. Rapid infiltration requires sandy loams, loamy sands, and sands. Module 3, "Soil as a Treatment Medium", discusses this topic.

The application rate of wastewater can also be affected if a constituent in the effluent is sufficiently concentrated to be applied in harmful amounts (Slide 52). Module 11, "Potentially Toxic Elements", discusses this subject.

Although salts or potentially toxic elements may be the limiting factor in some cases, nitrogen or hydraulic flow is the most common limiting factor for typical municipal wastewater systems (Slide 53). Module 15, "Nitrogen Considerations", discusses limits on nitrogen.

Another important consideration is the selection of a crop for an irrigation system. The choice should be based on the crop's ability to take up

nutrients, to control erosion, and to increase infiltration by maintaining pore space in the soil (Slide 54). The amount of revenue from crop harvest may also be considered. Module 20, "Crop Selection and Management Alternatives", discusses this topic.

The quality of the water after land treatment depends on the treatment method employed, the basic properties of the soil, the depth to bedrock, the nature of the wastewater applied and other factors. Removal capabilities can be similar for all three methods, although irrigation usually produces the highest quality of renovated water. As shown in Slide 55, irrigation removes up to 90% of the nitrogen and 80 to 99% of the phosphorus. Overland flow is the next most effective in nutrient uptake with 70 to 80% removal of nitrogen and 50 to 60% of phosphorus. Rapid infiltration is more effective with phosphorus at 70 to 95% removal, but its removal of nitrogen ranges from 0 to 80%.

Many established irrigation techniques developed for farming can be adapted to wastewater application. Although wastewater differs from irrigation water, it is suited to irrigation systems (Slide 56) because after settling, municipal wastewater contains less than 0.1 percent solids. Module 12, "Waste Application Systems", focuses on irrigation and other techniques for applying wastewater to the land.

The reactions of the public must be considered in any selection of waste treatment. Public health (Slide 57) is a concern in land application as with any other form of waste treatment. Module 9, "Pathogens", and Module 1, "Societal and Legal Constraints", discuss public concerns.

Studies have shown that with reasonable habits of personal hygiene and good management, health hazards from working on land application systems are not significant (Slide 58).

With most wastewater treatment facilities, monitoring programs are required by state and federal laws (Slide 59). Module 18, "Monitoring Land Application Systems", describes the laws and methods applying to monitoring. Laws may require analysis of both the groundwater and renovated water. Vegetation grown on the site may also be analyzed.

The soil is monitored in many states because it is recognized that applying wastewater to the land may change the soil characteristics. Monitoring practices largely depend upon the destination and ultimate use of the water (Slide 60).

After all the factors affecting land treatment of wastes are considered, it comes down to this. Which system is cheaper to build and operate and still produce the required quality of renovated water?

Slide 61 gives an overview of the costs of land application versus the costs of conventional secondary treatment. Module 10, "Costing Land Application Systems", discusses this topic.

Conventional waste treatment may be more cost-effective especially where large buffer zones are required around the land application areas, such as shown in this slide with the irrigated area surrounded by trees and positioned away from the road (Slide 62).

For small flow volumes of wastewater, the total cost of land application is very sensitive to the cost of moving effluent to the site. Therefore, transportation of the effluent for long distances to the site may make conventional treatment more cost effective (Slide 63).

At the same time, other factors may favor land application over conventional treatment. Income from agricultural crops grown on the site may reduce the total cost of operating and maintaining the land application system (Slide 64). The $3.1 million operating costs of the Muskegon County system were reduced $700,000 in 1975 by revenues from selling corn raised on the site.

Likewise, land application requires less energy to operate than conventional treatment plants. This becomes more important with increasing energy costs (Slide 65).

Costs are competitive between land application and conventional secondary treatment (Slide 66). Furthermore, land application produces a higher quality of treated water. The quality of renovated water that results from land application is about the same as from physical-chemical tertiary treatment (Slide 67). Module 4, "Treatment Systems, Effluent Qualities and Costs", discusses methods of pretreatment necessary for desired water quality and the accompanying costs.

Finally, it is important to remember that land application is site specific (Slide 68). It is not possible to establish a standardized design for all situations. Instead, the designer must rely on the knowledge of specialists in many fields to arrive at the best plan for each situation. This is emphasized throughout the educational program, especially in Module 2, "Site Evaluation: General Criteria - Information Sources", which indicates

site selection parameters and sources of assistance for information and design.

The intent of this educational program on the Land Application of Wastes is to help those associated with planning, designing, operating, evaluating, or regulating waste treatment facilities gain knowledge about all aspects of land application (Slide 69). The new emphasis on land application as an alternative to conventional waste treatment stems from its potential to control pollutants, eliminate their discharge and recycle essential nutrients as well as its cost effectiveness. Cornell's Land Application of Wastes Educational Program utilizes the most effective educational techniques to help the participant gain information concerning effective wastewater and sludge treatment techniques.